FALL 2010 VOL. 52 NO.1

MITSloan
Management Review

Interview by Michael S. Hopkins

How Sustainability Fuels Design Innovation

REPRINT NUMBER 52109

One solution to reducing use of materials that have high environmental impacts is to substitute "greener" ones. Here: Danilo Masuelli and one of his bikes that swap steel for bamboo.

How Sustainability Fuels Design Innovation

The link between sustainability and innovation is commonly mentioned, but not commonly made. Here, new-product design guru Steven Eppinger describes the *practice* that breeds discovery.

INTERVIEW BY MICHAEL S. HOPKINS

THERE'S AN ALARMIST VIEW of sustainable design that tilts toward the black and white. Industrial product life cycle: *bad*. Biological life cycle: *good*. Want to redesign things so they don't poison the environment? Then complete the comprehensive life cycle analysis of the product's impacts — all of them — before you think of lifting a design tool.

And fair enough; all-or-nothing reinvention is one fine path to creating something new.

It's not the best path, though, says new-product design expert Steven Eppinger. Eppinger is no less alarmed than the alarmists, but when it comes to the practice of what he calls "design for environment," he rejects the radical and argues for the incremental. For one thing, all-or-nothing isn't an approach businesses are especially good at; it takes too long, and fails too often. For another, the sum of continuous incrementalism is likely, he says, to carry designs further toward the no-impact outcomes everyone desires. Plus, there's a method to it. It can be learned. The secret is to focus on materials.

Eppinger, an engineer by training, is professor of management science and innovation at the

THE LEADING QUESTION

How can environmental concerns drive product design and innovation?

FINDINGS

- **Frame design and product innovation for environmental sustainability as a materials problem.**
- **How *much* material is used is less important than *what* material is used.**
- **Don't try to eliminate environmental impacts all at once. Try to get a little better each time you design any product.**

COURTESY OF FLICKR USER RICHARDMASONER

MIT Sloan School of Management, where he also has spent stints helping run the school as a deputy dean. He is coauthor, with Karl Ulrich, of the popular textbook *Product Design and Development*. (Its fifth edition, out next summer, contains a chapter titled "Design for Environment.")

In person, the word Eppinger calls to mind is crisp. His manner is disciplined, his speech direct; the ideas that interest him tend toward the actionable.

All of which make him a perfect commentator about the sometimes abstract management notions that connect sustainability to innovation. Eppinger has seen the connection in the field — one clear step at a time.

He spoke with Michael S. Hopkins, editor-in-chief of *MIT Sloan Management Review*.

We're going to get to innovation, design and new product development — your specialties — but first I wonder if you could do some temperature-taking for us. As you've worked with executives and organizations over the past few years, how has their thinking about sustainability changed?

I think there's been a key transformation. The thinking first went from, "This is a bad thing" to "This is an OK thing" — and maybe we're getting to the point now where it's even, "This is a really good thing." Let me draw an analogy with quality management. When quality management became a big emphasis of management education and practice in the 1980s, I think the initial attitude of managers was, "Well, we could improve quality, but it will cost more."

And then after implementing it for a while, we realized that was wrong, that in fact good implementations of quality management also improved cost. It was bad implementations of quality management that worsened costs. This is the transformation that we're now beginning to experience with sustainability. At first people said, "If I'm going to reduce the environmental impact of my product or service or business, cost will suffer, of course." It was just an assumption — a gut reaction — with lots of bad examples to support it.

So it's the bad implementations of sustainability that will affect cost in a bad way. But the good implementations — and there are plenty of examples today — save money.

So far, the most common way that companies attack sustainability is by making a pure operations play: identifying cost savings in cutting down on waste, improving on energy use. It's what lots of sustainability people call the early win, low-hanging fruit that every company could gain from doing. Is that kind of resource-efficiency thinking related to what you call "design for environment"?

No, not really. The way to think of environmental sustainability when it comes to design and product innovation is by framing it as a *materials problem*. It's about the materials that we use in the products and the materials that are used to run the processes that make the products. The reason that product design has a big impact is that's where the materials decisions are made.

If you want to have a product that uses only materials that can be recycled, you've got to rethink the product. You've got to change the design, which means new specifications and perhaps some difficult technical trade offs to deal with. If you want to use materials that are recycled in the first place instead of always using virgin materials, you've got to design the product differently so that can happen. If you want to reduce the use of packaging materials in operations, you've got to design the product differently so that it needs less packaging or no packaging; if you want to reduce the use of coatings and finishes, you've got to design the product so that it works properly and looks great without coatings and finishes. If you want to sell a product that your consumer can recycle, you've got to design the product to be easily disassembled and separated into available recycling streams.

The way I see it, sustainability is fundamentally a materials problem, and there's only so much you can do in operations.

Nevertheless, the "low-hanging fruit," as you call it, often is indeed in operations, so this is a great place to start. Here's why: Only after you've reached the limits of what you can do by just changing operations will you realize that much of the remaining bad stuff that's happening in operations and production, all of the toxins and wastes, are *designed in*. It's only when you realize that that you'll have traction in product redesign.

The impediment is that you have to be smart enough to do it. Sure, it's a no-brainer for the executive to say, "We'd like you to improve environmental performance, and reduce cost at the same time." That's [easy] … But it's one thing to believe that there are good solutions out there; it's another thing to actually find [them]. — STEVEN EPPINGER

Tell us about a company where you've seen this progression from resource efficiency to design solutions.

I've got a great example: Herman Miller. Herman Miller is a company that's really taken environmental awareness to heart.

I went to Herman Miller last year to talk with them about design for environment — design of their products for environmental sustainability. At first, they started telling me about all these operational things. They told me that in 1991 they developed a goal of completely eliminating the landfill waste they create. We were at their facility in Holland, Michigan — a factory operation that makes 10,000 chairs a day. A couple thousand people work there. They've got marketing, they've got cafeterias, they've got people doing design and drawing and sales and planning. And that kind of operation would normally create truckloads of waste that goes into a landfill, from cafeteria waste to packaging to office waste in trash bins.

They set a goal of zero almost 20 years ago, and today they send just 30 pounds of waste to the landfill per month — per month, out of the entire operation! And I'm thinking, how do they do that? Then I look in the corner of this conference room where we're having our meeting and there's a bin for recycling plastics, a bin for recycling metals, a bin for recycling papers, a bin for combustibles and another bin for compostables.

They told me they've gotten to the point where no one wants to be the person to put something in the trash to go to the landfill, and the same goes for the operations and purchasing managers who order materials and packaging and cleaners and oils.

Everything you buy ends up in the landfill or into one of the other bins, and if you don't think about it, it's probably going to be the landfill bin, right? But if you *do* think about it as, well, we buy this and it's going to go into the paper bin, the plastics bin or the compostables bin, then they have to make sure there's a mechanism to get it into those three streams. And they started to rethink everything they did.

So far you're talking about operations questions, right? But then Herman Miller shifted into thinking about design and sustainability?

This is what I mean when I say this is a materials problem. Companies end up thinking, "Everything we do, everything we buy, is materials, and where are they going to go?"

So yes, after Herman Miller achieved huge success for 10, 15 years on reducing, reducing, reducing their landfill, they then realized that they'd reached the limits of what they can do with that, because they engineer a lot of that waste and scrap and landfill into the product.

So think about a tabletop, for instance, that's made of wood and has a laminate on the top and a laminate on the side. The laminate's plastic and the scraps can go into the plastic recycling, and the wood is a natural material, and it can actually go into the compostable recycling.

But once you bond them together and then you trim the edge, any scrap you now cut away can't go into either, because it's partly compostable and partly recyclable. Now it's a combination and it has to be landfilled. And that's when they started to redesign and re-engineer their products. They were able to get engineering and design and supply chain functions fully involved. And that's a powerful transformation.

Great example. There aren't a lot of companies like Herman Miller, but say a company finds this sustainable design idea compelling and knows this is a path they want to go down. So they want to figure out the first step. What do you ask them to think about?

Again, I say it's a materials problem. And it's actually not how *much* material you use. I don't think that matters a whole lot. I think what matters is *what* materials you use, and what happens to them after you've used them. Do they get composted, do they get recycled or do they get landfilled? Do they degrade? Do they put toxins into the environment?

Are you including things like the glues and finishes and treatments?

Yes. Every single raw material that you use. This is sometimes called cradle-to-cradle thinking, which William McDonough and Michael Braungart wrote a really nice book on. I've found that a good way to engage companies in thinking about materials is to illustrate the life cycles of materials as they travel through either an industrial life cycle or a biological life cycle. See "Where Materials *Go* — Designing for Bio and Industrial Life Cycles, Combined," p. 81. If you look at the industrial cycle, you can follow what happens to all the industrial materials. We produce product with them, we distribute them, they go out into the world and get used and then hopefully we recover those materials. And how we recover those materials is really where the key decision point is.

What are some of the things that happen to materials at that junction?

Some materials get recovered by remanufacturing them directly into new products, like used toner cartridges that get made into new toner cartridges. Some materials get recycled by consumers back into the industrial materials cycle, such as our beverage bottles and cans. Some materials get reused, either for the same or a different purpose. Maybe a consumer uses their bulk CD packaging to hold a bagel sandwich for lunch. Of course, there are also intermediaries. When you're done with an old automobile, you don't actually return it to the manufacturer, you take it to the vehicle dismantler (what used to be called junkyards) and they separate most of it into different materials that are recycled or reused through the same industrial material cycle.

All good outcomes.

That's the point. If managed right, the industrial products cycle can be a very a good cycle. There's nothing inherently bad about that cycle except for one step in it: disposal. Now, if disposal feeds the biological cycle, that's OK too. I take my scraps from the dinner table and the waste from my garden and they go into my compost bin to create new resources that grow new food — that's a good bio cycle. The same for cotton and wood — if we can put them into an active biological composting process and turn them into new materials of the same types, that's a good cycle.

That's the first way to think of these cycles — to recognize that they're not necessarily bad, they're good. So what's the problem, in terms of sustainability and the environment? Basically, there are just three. The first is that toxins are created when we use toxic materials, and they don't get processed by the bio cycles — toxins sit there in the Earth's crust and make things toxic for a very long time. The second problem is that we're using a lot of nonrenewable resources. It's fine that we use wood, because it gets renewed pretty quickly, and it's OK that we use aluminum and silica and iron, because they can run around this industrial cycle over and over and over again, and it's only a problem if we fail to reuse them.

The third problem is energy. Most of the industrial cycle is being powered by fossil fuels — and in the process, creating toxins, which is a separate problem. Fossil fuels are a nonrenewable resource. Over 50 to 100 years, we've got to stop using nonrenewable energy. Basically stop. And that means slow now and stop eventually. The places in the world where they've really, really focused on that have made huge progress on transforming from nonrenewable to renewable energy. We've got to make more progress on that on a global scale.

This is the way that I start the discussion with a business. They realize that they're in the business of running these cycles and they make choices about what materials are in these cycles and they should take responsibility for the materials throughout the product life cycle.

How do executives react to this picture?

I think probably the most common reaction is, "Wow, this is a beautiful rosy academic picture. That's a nice way to think, but you know, we're just not in the materials business. We're in the business

of doing something that we've been doing for many years, and it's horribly wasteful and I don't see how we'll ever get to sustainability." So I think at first they see this and say, "We are so far from thinking about this in cycles … ."

OK, they throw their hands in the air. And then?

Well, there's still an important recognition in seeing that many of the materials we use and produce and that go around the cycle end up getting disposed and putting toxins into the environment. That recognition *does* lead to an opportunity.

The way to think about that is, What materials could we use that are still effective in the product but that don't create a problem? What if we made our materials selections from the list of materials that can go around this industrial materials cycle over and over and over again and still be useful? And there are plenty of materials that do that, it's just not all of the 200,000 materials we use in industry today; it's only a fraction of them. But if we were to limit ourselves to the fraction that actually can be recovered and recycled and reused without degradation, that would be a great place to start.

Frankly, that sounds too hard to do: "Limit all your materials choices to the small set that has no negative environmental impact; now go reinvent all your products accordingly."

Ah, well, the approach we teach is not to do it all at once. Instead, try to get a little bit better each time you design any product. That's where the thinking has to start. It's incremental: Can we improve a little bit this time? Yes. We might not be able to take out all of the materials that create toxins, but we can take out some of them. For example, PVC creates toxins that may create cancer. It's dangerous to produce and can't be disposed of effectively without releasing more toxins into the environment. Perhaps you can't design all the PVC out of your product today. But can you design half of it out now, and maybe all of it in a few years?

You talked about life cycle analysis — is that where companies should start in order to figure

out which materials to begin designing out of their products?

Probably not — at least not with very much precision. I know there are a lot of proponents of LCA, life cycle analysis, which is essentially a really detailed analysis of all the impacts of all the materials we use in all the different ways — but honestly, even with some of the best software out there today, it's really pretty tedious and difficult to conduct a full LCA for even one product. And when you're done, it says, "Oh, here's the impact of your product used and disposed of in a certain way." Trouble is, that doesn't reduce anything; it just tells you how bad it is.

So rather than a complete and detailed LCA, I find it really useful to simply conduct a qualitative assessment of the product's impact. Let's face it — most businesses know the biggest environmental impacts of their product or service. Then there are a lot of improvements that can be made incrementally in the right direction, which is all we're really trying to do to get started. We redesign and we substitute, and we make progress every time. We may never know the total impact because that's really hard and difficult to compute. But we know we're moving in the right direction. And so the fallacy of thinking that we have to do a really, really detailed assessment before we can make any improvement, I think may hamper some really important opportunities to make improvements in the right direction.

How large do you think the opportunity is for companies? Amory Lovins says he stands on the threshold of factories, watches how they work and thinks, "I feel like I'm looking at hundred-dollar bills sloshing around on the floor, there's so much inefficiency and waste." Do you feel like there's a 50% likelihood that companies can pursue environmentally sustainable design and very quickly get a net benefit from the investment? Eighty percent? Twenty?

I think there's 100% likelihood.

One hundred percent?

I believe that every company can improve in this area.

But at what cost? What's the return like?

Oh, it pays back. I mean, think about it: Buying all that packaging that you really don't need, that costs money. Disposing of those toxic materials, that's not cheap. And it will probably get more expensive as we put more appropriate prices on those things.

Okay, but there are downsides to all that, aren't there? You take away packaging and you might lose appeal in the marketplace.

Or you might improve it.

Or you might improve it.

You used what we call the hundred-dollar-bills-on-the-floor analogy in operations, and I think there are a lot of hundred-dollar bills in product design. There are ways that we can improve a product's design that reduce the use of expensive materials, that reduce the use of hazardous materials, that improve the working conditions in the factory, and all those things pay back.

So when I say there's 100% likelihood of companies getting a net benefit, I mean every company can find ways to improve their environmental performance through this kind of thinking. I really believe that.

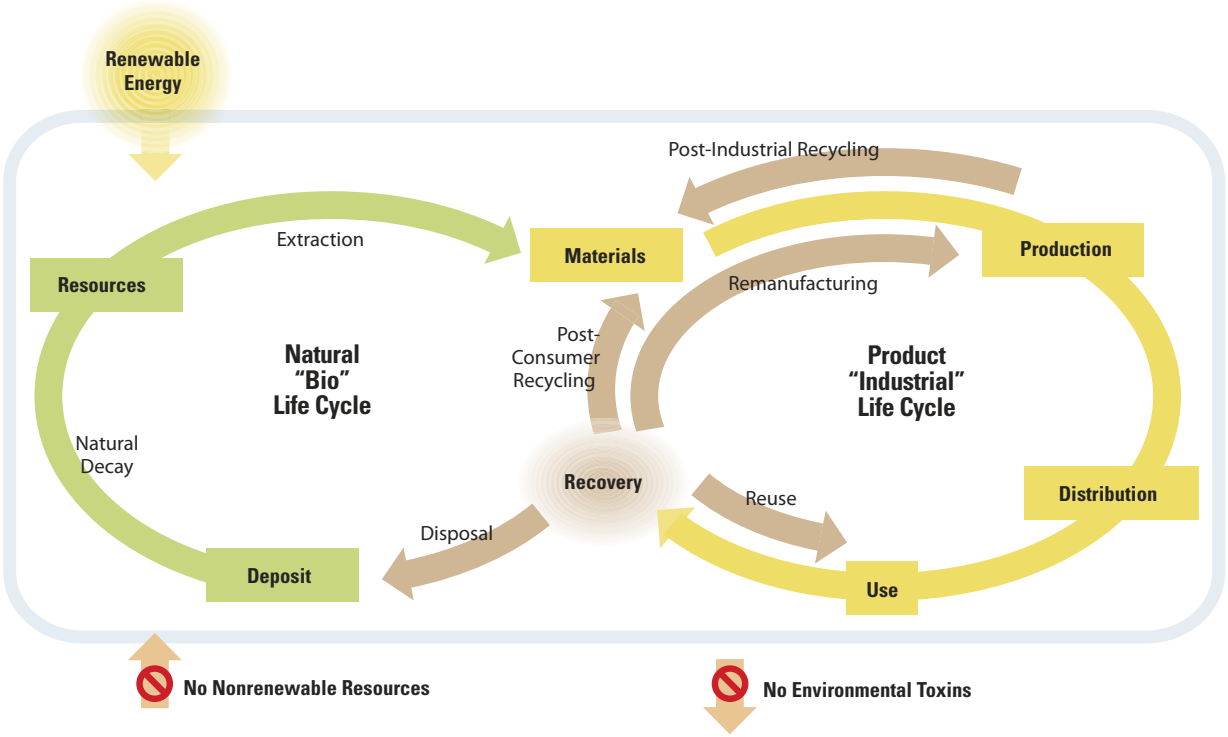
Is it the incremental changes that eventually lead you to product-design questions you might otherwise never have asked?

That absolutely happens. Some companies are thinking about fundamentally different ways to provide their service or develop their product or produce their product and they come up with a

EPPINGER: Think about what happens to [products] after you've used them. Do they get composted, recycled, landfilled? Do they degrade? Do they put toxins into the environment?

WHERE MATERIALS *GO* — DESIGNING FOR BIO AND INDUSTRIAL LIFE CYCLES, COMBINED

Companies can design bad materials out of their product and service cycles, both by replacing bad materials with better ones and by redesigning products enough that bad materials aren't necessary (or a lot less of them are necessary, anyway). Examining these cycles is how Eppinger starts the discussion with businesses pursuing sustainable design innovation.



radically different design that happens to also be better for the environment. In Herman Miller's case, they've thought about ways to develop chairs that weigh a whole lot less by removing material. They call it *dematerialization*. I don't know if they invented that word, but if it weighs half as much, it's going to use half as much material, and that alone may cut the environmental impact in half.

So I think these approaches go together. On the one hand, you just go until you reach a roadblock and then you may stumble upon a major innovation. At the same time, you also get people thinking about different ways of doing things. And then if you can use *all* safe and recyclable materials, well, that's a big, big leap in terms of environmental impact, after a lot of little steps along the way.

Last question: When you've persuaded executives to head in the direction you describe, and they go off to their organizations to make it so, what stops them from succeeding? What's the biggest impediment?

The impediment is that you have to be smart enough to do it. Sure, it's a no-brainer for the executive to say, "Go ahead and do this. We'd like you to improve the environmental performance, and reduce cost at the same time." That's an easy thing for the executive to do. But those who have to actually implement it — the managers who are now thinking about the whole supply chain and the engineers who are now designing the product with new trade offs — they have to find the right materials. So there's still hard work to do, and I think that's the impediment, how do we actually do it. It's one thing to believe that there are good solutions out there; it's another thing to actually find those good solutions.

To do this, I've found that we need better processes, better methods for how to design products and services. That's where my work has been, in developing the better processes and methods for design. That's the process we call product design for environment.

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